CBSE Class 11 Physics

Sample Paper 10 (2020-21)

Maximum Marks: 70

Time Allowed: 3 hours

General Instructions:

i. All questions are compulsory. There are 33 questions in all.
ii. This question paper has five sections: Section A, Section B, Section C, Section D and Section E.
iii. Section A contains ten very short answer questions and four assertion reasoning MCQs of 1 mark each, Section B has two case based questions of 4 marks each, Section C contains nine short answer questions of 2 marks each, Section D contains five short answer questions of 3 marks each and Section E contains three long answer questions of 5 marks each.
iv. There is no overall choice. However internal choice is provided. You have to attempt only one of the choices in such questions.

Section A

1. What is a scalar?
2. Bodies of larger mass need greater initial effort to put them in motion. Why?

   OR

   Which of the following is scalar quantity? Inertia, force and linear momentum.
3. Two particles in an isolated system under go head on collision. What is the acceleration of the centre of mass of the system?
4. At what factor between the two particles, gravitational force does not depend?

   OR

   What is the weight of a body in a geostationary satellite?
5. Why does the cloud seem floating in the sky?

6. If unit vectors $\hat{a}$ and $\hat{b}$ are inclined at angle θ, then prove that $|\hat{\mathbf{a}}-\hat{\mathbf{b}}| = 2\sin\frac{\theta}{2}$.
7. Which of these is the largest: astronomical unit, light year and parsec?

OR

If velocity, time and force were chosen the basic quantities, find the dimensions of mass?

8. A steel wire 0.72 m long has a mass of 5.0×10^{-3} kg. If the wire is under r a tension of 60 N, what is the speed of transverse waves on the wire?

OR

What is the nature of water waves produced by a motorboat sailing in water?

9. Why water at the base of a waterfall is slightly warmer than at the top?
10. What is the average value of acceleration vector in uniform circular motion over one cycle?
11. **Assertion:** A cyclist always bends inwards while negotiating a curve.
Reason: By bending he lowers his centre of gravity.
    a. Assertion and reason both are correct statements and reason is correct explanation for assertion.
    b. Assertion and reason both are correct statements but reason is not correct explanation for assertion.
    c. Assertion is correct statement but reason is wrong statement.
    d. Assertion is wrong statement but reason is correct statement.
12. **Assertion:** Ductile metals are used to prepare thin wires.
Reason: In the stress-strain curve of ductile metals, the length between the points representing elastic limit and breaking point is very small.
    a. Assertion and reason both are correct statements and reason is correct explanation for assertion.
    b. Assertion and reason both are correct statements but reason is not correct explanation for assertion.
    c. Assertion is correct statement but reason is wrong statement.
    d. Assertion is wrong statement but reason is correct statement.
13. **Assertion:** The ratio $\frac{C_P}{C_V}$ for a monoatomic gas is more than for a diatomic gas
Reason: The molecules of a monoatomic gas have more degree of freedom than those of a diatomic gas.

a. Assertion and reason both are correct statements and reason is correct explanation for assertion.
b. Assertion and reason both are correct statements but reason is not correct explanation for assertion.
c. Assertion is correct statement but reason is wrong statement.
d. Assertion is wrong statement but reason is correct statement.

14. **Assertion:** A quick collision between two bodies is more violet than slow collision, even when initial and final velocities are identical.
Reason: The rate of change of momentum determines that the force is small or large.
a. Assertion and reason both are correct statements and reason is correct explanation for assertion.
b. Assertion and reason both are correct statements but reason is not correct explanation for assertion.
c. Assertion is correct statement but reason is wrong statement.
d. Assertion is wrong statement but reason is correct statement.

Section B

15. **Read the case study given below and answer any four subparts:**
In a small but crowded room, we start to feel very warm and will start sweating. Heat from our body is transferred to the sweat. As the sweat absorbs more and more heat, it evaporates from your body, becoming more disordered and transferring heat to the air, which heats up the air temperature of the room. Many sweating people in a crowded room, that acts as 'closed system' will quickly start heating things up.

i. By the first law of thermodynamics:
a. $Q = \Delta E - W$
b. $Q = \Delta E + W$
c. $Q = -\Delta E - W$
d. none of these

ii. Which of the following can be considered as the definition of energy?

a. $Q = \Delta E + W$
b. first law of thermodynamics
c. both a and b
d. none of these

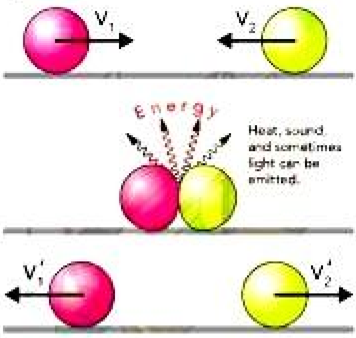
iii. Internal energy is defined by:
a. Zeroth law of thermodynamics
b. first law of thermodynamics
c. Second law of thermodynamics
d. none of these

iv. When a system is in equilibrium, any change in entropy would be:
a. maximum
b. zero
c. positive
d. negative

v. The second law of thermodynamics defines:
a. Heat
b. Work
c. energy
d. enthalpy

16. **Read the case study given below and answer any four subparts:**

An **elastic collision** is a **collision** in which there is no net loss in kinetic energy in the system as a result of the **collision**. Both momentum and kinetic energy are conserved quantities in **elastic collisions**.



i. In which motion, momentum changes but K.E does not?
a. circular motion
b. parabolic motion
c. straight line motion

d. none of these

ii. coefficient of restitution for elastic collision is:

a. 0

b. 1

c. -1

d. infinite

iii. Two balls at the same temperature collide. What is conserved?

a. momentum

b. velocity

c. kinetic energy

d. none of these

iv. Momentum of two objects moving with the same speed but in opposite direction upon collision is

a. increased

b. decreased

c. zero

d. none of these

v. In elastic collision, the relative speed of approach and separation is:

a. equal

b. unequal

c. zero

d. infinite

Section C

17. A body weighs 63 N on the surface of the earth. What is the gravitational force on it due to the earth at a height equal to half the radius of the earth?

18. 100 g of water is super cooled to –10°C. At this point, due to some disturbance mechanized or otherwise some of it suddenly freezes to ice. What will be the temperature of the resultant mixture and how much mass would freeze?
[$S_w = 1cal/g/^\circ C$ and $L^W_{fusion} = 80cal/g$]

OR

What kind of thermal conductivity and specific heat requirements would you specify for cooking utensils?

19. A man stands on a weighing machine placed on a horizontal platform. The machine reads 50 kg. By means of a suitable mechanism, the platform is made to execute harmonic vibrations up and down with a frequency of two vibrations per second. What will be the effect on the reading of the weighing machine? The amplitude of vibrations of platform is 5 cm. Take g =10 ms^{-2}.

OR

The Vertical motion of a huge piston in a machine is approximately S.H.M with a frequency of 0.5 S". A block of 10kg is placed on the piston. What is the maximum amplitude of the piston's S.H.M. for the block and piston to remain together?

20. What is kinetic friction? Is it self-adjusting?
21. Two trains A and B of length 400 m each are moving on two parallel tracks with a uniform speed of 72 km h^{-1} in the same direction, with A ahead of B. The driver of B decides to overtake A and accelerates by $1 m/s^2$. If after 50 s, the guard of B just brushes past the driver of A, what was the original distance between them?
22. What is the direction of oscillations of the particles of a medium through which
    i. transverse,
    ii. Longitudinal wave is propagating.
23. Although both torque and work are defined as force multiplied by distance, they differ in there physical meaning. Why?
24. It is a well-known fact that during a total solar eclipse the disk of the moon almost completely covers the disk of the Sun. From this fact determine the approximate diameter of the moon.

OR

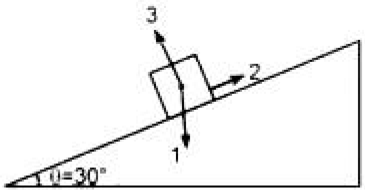
The voltage across a lamp is V = (6.0 ± 0.1) Volt and the current passing through it is (4.0 ± 0.2) ampere. Find the power consumed by the electric lamp. Given that power, P = VI.

25. A driver takes 0.20 second to apply the breaks (reaction time). If he is driving car at a speed of 54 kmh^{-1} and the breaks cause a deceleration of 6.0 ms^{-2} , find the distance travelled by car after he sees the need to put the breaks.

Section D

26. A block of wood of mass 3 kg is resting on the surface of a rough inclined surface,

inclined at an angle $\theta = 30°$ as shown in the figure.



a. Name the forces 1, 2 and 3.

b. If the coefficient of friction is 0.2, calculate the value of all the three forces, ($g = 10 ms^{-2}$)

27. Two resistors of resistances $R_1 = (100 \pm 3)\ \Omega$ and $R_2 = (200 \pm 4)\Omega$ are connected (i) in series, (ii) in parallel. Find the equivalent resistance of the (i) series combination (ii) parallel combination.

OR

Briefly discuss different types of systematic errors.

28. Two bodies are thrown with the same initial velocity at angles, α and $(90° - \alpha)$ with the horizontal. What will be the ratio of
   i. maximum heights attained by them and
   ii. their horizontal ranges

OR

A clever strategy in a snowball fight is to throw two snowballs at your opponent in quick succession. The first one is thrown with a high trajectory (path) and the second one with a lower trajectory and a shorter time of flight. This is so that they both reach the target at the same instant.

Suppose your opponent is 20 m away. You throw both snowballs with the same initial speed v_0 but θ_0 is 60° for the first snowball and 30° for the second. If they both reach their target at the same instant, how much time must pass between the release of the two snowballs?

29. State work-kinetic energy theorem and prove it analytically.
30. An object of mass m is raised from the surface of the earth to a height equal to the radius of the earth, it is taken from a distance R to 2R from the centre of the earth. What is the gain in its potential energy?

Section E

31. One end of a V-tube containing mercury is connected to a suction pump and the other

end to atmosphere. The two arms of the tube are inclined to horizontal at an angle of 45° each. A small pressure difference is created between two columns when the suction pump is removed. Will the column of mercury in V-tube execute simple harmonic motion? Neglect capillary and viscous forces. Find the time period of oscillation.

OR

You are riding in an automobile of mass 3000 kg. Assuming that you are examining the oscillation characteristics of its suspension system. The suspension sags 15 cm when the entire automobile is placed on it. Also, the amplitude of oscillation decreases by 50% during one complete oscillation. Estimate the values of (a) the spring constant k and (b) the damping constant b for the spring and shock absorber system of one wheel, assuming that each wheel supports 750 kg.

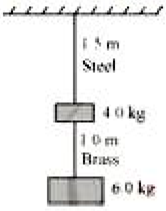
32. On the basis of equipartition law of energy find expressions for the principal molar specific heats of gas as well as for γ (the ratio of two specific heats) for gas having n degrees of freedom per molecule.

OR

Explain why

a. there is no atmosphere on moon.
b. there is fall in temperature with increase in altitude.

33. Two wires of diameter 0.25 cm, one made of steel and the other made of brass are loaded as shown in Figure. The unloaded length of steel wire is 1.5 m and that of brass wire is 1.0 m. Compute the elongations of the steel and the brass wires.



OR

Consider a steel rod having a radius of 8 mm and the length of 2m: If a force of 150 kN stretches it along its length, then calculate the stress and percentage strain in the rod if the elongation in length is 7.46 mm.

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Solution

Section A

1. A scalar is a quantity that is fully described by a magnitude only. It is described by just a single number. Some examples of scalar quantities include speed, volume, mass, temperature, power, energy, and time.
2. According to Newton's second law of motion, F = ma, for given acceleration a, if m is large, F should be more i.e. greater force will be required to put a larger mass in motion as it is essential for the law of motion.

OR

Inertia and linear momentum is measured by mass of the body and is a vector quantity and mass is a scalar quantity.

3. Acceleration is zero, as forces are internal forces.
4. Gravitational force does not depend upon the medium between the two particles.

OR

In a geostationary satellite, the weight of a body is zero

5. The terminal velocity of a raindrop is directly proportional to the square of radius of drop. When falling, bigger drops have higher terminal velocities than smaller drops. Hence the small drops falls so slowly that cloud seems floating.
6. For any vector $\vec{a}$,

$\Rightarrow |\mathbf{a}|^2 = \mathbf{a} \cdot \mathbf{a}$
$\therefore |\hat{\mathbf{a}} - \hat{\mathbf{b}}|^2 = (\hat{\mathbf{a}} - \hat{\mathbf{b}}) \cdot (\hat{\mathbf{a}} - \hat{\mathbf{b}})$
$= \hat{\mathbf{a}} \cdot \hat{\mathbf{a}} - \hat{\mathbf{a}} \cdot \hat{\mathbf{b}} - \hat{\mathbf{b}} \cdot \hat{\mathbf{a}} + \hat{\mathbf{b}} \cdot \hat{\mathbf{b}}$
$= 1 - 2\hat{\mathbf{a}} \cdot \hat{\mathbf{b}} + \mathbf{1}$
$= 2 - 2 \times 1 \times 1 \times \cos\theta$
$= 2(1 - \cos\theta)$
$= 2.2\sin^2\frac{\theta}{2} = 4\sin^2\frac{\theta}{2}$

Hence, $|\hat{\mathbf{a}}-\hat{\mathbf{b}}|=2\sin\frac{\theta}{2}$

7. Parsec (1 parsec = 3.27 light years) is larger than a light year which in turn is larger than an astronomical unit (AU).

   $1\text{ lyr}=9.46\times10^{15}\text{m}$

   $1\text{pc}=3.08\times10^{16}\text{m}1\text{AU}=1.5\times10^{11}\text{m}$

OR

force = mass $\times$ acceleration

force = mass $\times\frac{\text{velocity}}{\text{time}}$

$\frac{\text{time}\times\text{force}}{\text{velocity}}$ = mass

mass = $\frac{FT}{V}$

mass = $[FTV^{-1}]$

8. Mass per unit length of the wire

   $\mu=\frac{5.0\times10^{-3}\text{kg}}{0.72\text{m}}$

   = 6.9×10^{-3} kgm^{-1}

   Tension, T = 60 N

   Speed of the transverse wave through the wire, v = $\sqrt{\frac{T}{\mu}}=\sqrt{\frac{60}{6.9\times10^{-3}}}$ = 93 ms^{-1}

OR

Water waves produced by a motorboat sailing in water are both longitudinal and transverse.

9. Potential energy converted in to kinetic energy, some part of kinetic energy is Converted in to heat.
10. The acceleration vector of a particle in uniform circular motion averaged over one cycle is a null vector.
11. (b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

    Explanation: Both assertion and reason are true but reason is not the correct explanation of assertion.

    By bending the cyclist obtains the necessary centripetal force. Though he also lowers his centre of gravity by bending, but it is not the correct explanation of assertion given in the question. Hence, both A and R are true but R is not the correct explanation of A.

12. (c) Assertion is correct statement but reason is wrong statement.

Explanation: Let a uniform cylinder of length l have volume V. Then its uniform cross-sectional area,

$A = \frac{V}{l}$

Let a force F be applied to compress the cylinder; then stress in it will be S = F/A and the strain will be,

$\sigma = \frac{S}{Y} = \frac{F/A}{Y} = \frac{F}{AY}$

where Y is Young's modulus of elasticity of the material of the cylinder.

Volumetric strain, $\sigma_V = \sigma(1 - 2\mu)$

where μ is Poisson's ratio

or $\sigma_V = \frac{F}{AY}(1 - 2\mu)$

Decrease in volume

$\Delta V = V\sigma_V = Al\frac{F}{AY}(1 - 2\mu) = \frac{Fl}{Y}(1 - 2\mu)$

Since, ΔV is independent of A and is directly proportional to original length l, hence only this option is correct.

13. (c) Assertion is correct statement but reason is wrong statement.

Explanation: Assertion is correct statement but reason is wrong statement.

14. (a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

Explanation: In a quick collision, time t is small. As F $\times$ t = constant. Therefore, force involved is large, i.e., collision is more violent in comparison to slow collision.

Section B

15. i. b
 ii. c
 iii. b
 iv. b
 v. d

16. i. a
 ii. b
 iii. a
 iv. c

v. a

Section C

17. Suppose g_h be the acceleration due to gravity at a height equal to half the radius of the earth $h=\frac{R}{2}$

As we know,

$\frac{g_h}{g}=\left(\frac{R}{R+h}\right)^2$ or $\frac{g_h}{g}=\left(\frac{R}{R+\frac{R}{2}}\right)^2=\left(\frac{2}{3}\right)^2=\frac{4}{9}$

W = the weight of the body on the surface of the earth

W_h = the weight of the body at height h.

$\Rightarrow, \frac{W_h}{W}=\frac{mg_h}{mg}=\frac{g_h}{g}=\frac{4}{9}$

$\Rightarrow W_h=\frac{4}{9}W=\frac{4}{9}\times 63N=28N$

18. Water mass = 100 g

At -10^oC ice and water mixture exists.

Heat required (given out) by $-10^\circ C$ ice to $0^\circ C$ ice = $ms\Delta t$

$=100\times 1\times[0-(-10)]$

$Q=1000\text{cal}$

Let gm of ice melted Q = ml

$m=\frac{Q}{L}=\frac{1000}{80}=12.5g$

So, there is m = 12.5 g water and ice in mixture. Hence temperature of mixture remains $0^\circ C$.

OR

A cooking utensil should have-

i. Low specific heat so that it immediately attains the temperature of the source.
ii. High conductivity, so that it can conduct heat through itself and transfer it to the contents quickly.

19. Here, mass (m) = 50 kg, frequency(ν) = 2 s^{-1}, amplitude (A) = 5 cm =0.05 m

Maximum acceleration,

$a_{max}=\omega^2 A=(2\pi\nu)^2 A=4\pi^2\nu^2 A$ ms^{-2}

$=4\times\left(\frac{22}{7}\right)^2\times(2)^2\times 0.05$ = 7.9 ms^{-2}

Maximum force felt by the man, R_{max}

$m(g + a_{max}) = 50(10 + 7.9) = 895.0$ N = 89.5 kgf (since 1 kgf force = 1 kg × 10 ms^{-2} = 10 N)

Minimum force felt by the man, R_{min}

$= m(g - a_{max}) = 50(10 - 7.9)$

= 105.5 N = 10.5 kgf [g being acceleration due to gravity]

Hence, the reading of the weighing machine varies between 10.5 kgf and 89.5 kgf.

OR

Given, $v = 0.5s^{-1}$ $g = 9.8ms^{-1}$

$$a = \omega^2 y = (2\pi v)^2 y = 4\pi^2 v^2 y$$

a_{max} at the extreme position i.e. r = y

$a_{max} = 4\pi^2 v^2 r$ and a_{max} = g to remain in contact.

Or $r = \frac{g}{4\pi^2 v^2} = \frac{9.8}{4\pi^2 \times (0.5)^2} = 0.993\text{m}$

20. Kinetic friction is the force of friction which comes into play between the surfaces of contact of two bodies when one body is in steady motion over the surface of another body. Kinetic friction is not self-adjusting. Rather it has a constant value for a given normal reaction.

21. **For train A:**

Initial velocity, u = 72 km/h = 20 m/s

Time, t = 50 s

Acceleration, $a_I = 0$ (Since it is moving with a uniform velocity)

From second equation of motion, distance (S_I) covered by train A can be obtained as:

$$s_I = ut + \frac{1}{2}a_I t^2$$

= 20 × 50 + 0 = 1000 m

For train B:

Initial velocity, u = 72 km/h = 20 m/s

Acceleration, a = 1 m/s^2

Time, t = 50 s

From second equation of motion, distance (S_{II}) covered by train A can be obtained as:

$$s_{II} = ut + \frac{1}{2}at^2$$

$$= 20 \times 50 + \frac{1}{2} \times 1 \times (50)^2 = 2250\text{m}$$

Length of both trains = 2 × 400 m = 800 m

Hence, the original distance between the driver of train A and the guard of train B is 2250 - 1000 - 800 = 450 m.

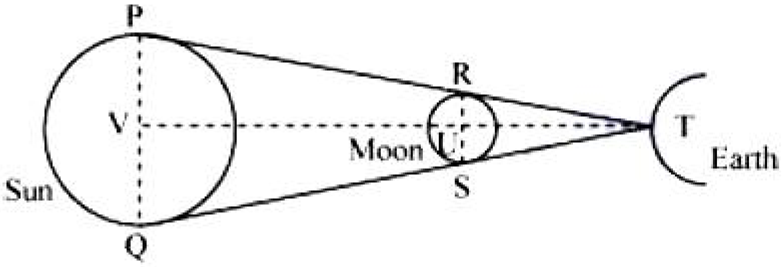
22. i. In a transverse wave, the medium particles periodically oscillate to and fro about their mean positions in a direction perpendicular to that of the propagation of a wave.

 ii. In a longitudinal wave, the medium particles oscillate to and fro about their mean positions along the same line as that of propagation of the wave.

23. Although both torque and work are defined as force multiplied by distance, they differ in their physical meanings. Work is a scalar quantity and is equal to the scalar product of force and displacement i.e., W = $\vec{F}.\vec{s}$ = F s cos θ.

Torque is a measure of the rotational effect of force about an axis and is equal to the vector product of force and position vector of point of application of force from the rotational axis i.e., $\vec{\tau}=\vec{r}\times\vec{F}=Fr\sin\theta\,\hat{n}$

24.



The position of the Sun, Moon, and Earth during a lunar eclipse is shown in the given figure.

Distance of the Moon from the Earth = 3.84×10^{8} m

Distance of the Sun from the Earth = 1.496×10^{11} m

Diameter of the Sun = 1.39×10^{9} m

It can be observed that ΔTRS and ΔTPQ are similar. Hence, it can be written as:

$\frac{1.39\times10^{9}}{\mathrm{RS}}=\frac{1.496\times10^{11}}{3.84\times10^{8}}$

$RS=\frac{1.39\times3.84}{1.496}\times10^{6}=3.57\times10^{6}\mathrm{m}$

Hence, the diameter of the Moon is 3.57×10^{6} m.

OR

As, V = (6.0 ± 0.1) V and I = (4.0 ± 0.2) A

Since, Power consumed, P = VI = 6.0 × 4.0 = 24 W

and relative error in power measurement is given by:

$\frac{\Delta P}{P}=\frac{\Delta V}{V}+\frac{\Delta I}{I}=\frac{0.1}{6.0}+\frac{0.2}{4.0}$

$= 0.017 + 0.050 = 0.067$

$\Delta P = 0.067 \times P$

$= 0.067 \times 24 =$ 1.6 Watt

Power consumed within error limits is (24 ± 1.6) Watt.

25. The car is moving at speed of 54 km/hr = 15 m/sec i.e, initial speed after applying brakes is (u) = 15 m/sec

Say at point A, he sees the need to put brakes and at point B, he puts brakes and then the car starts deceleration and at point C, the car finally comes to rest.

From A to B it moves with speed of 15m/sec in 0.2 sec.

So distance covered is S_1 = v x t = 15 x 0.2 = 3 m and from B to C it moves with constant deceleration of -6 m/sec^2 and initial speed of 15m/sec.

Here, final velocity is zero as car comes to rest finally. Using relation $v^2 - u^2 = 2(-a)s$, we have

$S_2 = \frac{u^2}{2a} = \frac{15\times 15}{2\times 6}$ = 18.75 m

Hence, the distance traveled by car after he sees need to put brakes = $S_1 + S_2$ = 3 + 18.75 = 21.75 m

Section D

26. a. Force 1 = The weight mg acting vertically downwards

Force 2 = The static frictional force opposing the impending motion

Force 3 = The normal force of the plane of the block

b. Here m is mass of body and g is value of acceleration due to gravity.

Thus, Force 1 = m g = 3 × 10 = 30 Newton

If θ = 30° and μ = 0.2 then angle θ is greater than the angle of repose. Hence the force of friction f has its maximum value $f_m = \mu mg \cos\theta$.

Therefore, Force 2 = $\mu mg \cos\theta = 0.2 \times 3 \times 10 \times \cos 30^\circ$ = 5.2 Newton

Force 3 = mg cos θ = 26 Newton

27. Here, $R_1 = (100 \pm 3)\ \Omega$, $R_2 = (200 \pm 4)\ \Omega$

i. **Resistance in Series combination**

$R = R_1 + R_2 = 100 + 200 = 300\ \Omega$

$\Delta R = \pm(\Delta R_1 + \Delta R_2)$

$= \pm(3 + 4) = \pm 7\ \Omega$

$\therefore \quad R = (300 \pm 7)\Omega$

ii. **Resistance in Parallel Combination**

$\frac{1}{R'} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{R_2+R_1}{R_1 R_2} = \frac{200+100}{100\times200} = \frac{300}{20000} = \frac{3}{200}$

$R' = \frac{200}{3}$ = 66.66667 $= 66.7\Omega$ [upto one decimal place]

$\frac{\Delta R'}{R'^2} = \pm\left[\frac{\Delta R_1}{R_1^2} + \frac{\Delta R_2}{R_2^2}\right]$

$\Delta R' = \pm\left[\Delta R_1\left(\frac{R'}{R_1}\right)^2 + \Delta R_2\left(\frac{R'}{R_2}\right)^2\right]$

$= \pm\left[3\left(\frac{200}{3\times100}\right)^2 + 4\left(\frac{200}{3\times200}\right)^2\right] = \pm\left[3\left(\frac{4}{9}\right) + 4\left(\frac{1}{3}\right)\right] = \pm 1.8\ \Omega$

Hence, the equivalent resistance along with error in parallel combination is = (66.7 ± 1.8) Ω

OR

Systematic errors are those errors that tend to be in one direction, either positive or negative. It is a repeatable error. Different types of systematic errors are:

i. **Instrumental errors:** These arises from the errors due to imperfect design or calibration of the measuring instrument. Zero error present in vernier calliper, backlash error in screw gauge / spherometer, etc., are examples of instrumental errors. Appropriate corrections may be applied for these errors.

ii. **Errors due to imperfection in experimental technique or procedure:** For example, a nurse tries to measure the body temperature of a young child by placing the thermometer under his armpit. Naturally, the temperature is less than the real body temperature and produces an error. Similarly, heat loss due to radiation in calorimetry experiments or effect of buoyancy of air while weighing a body are errors of this type.

iii. **Environmental Errors (Errors due to external cause):** These errors are due to external conditions like change in temperature, atmospheric pressure, humidity, wind velocity etc., during the course of experiment. Effect of these errors may be eliminated by performing experiment under different external conditions spread over a long time and then taking the mean value.

iv. **Personal errors:** These errors arise due to an individual's bias, lack of proper setting of apparatus or carelessness of the observer while taking the observations. To minimize these errors the person performing an experiment should be extremely careful and should follow proper procedures.

28. i. When the angle of projection is α, the maximum height is $H_1 = \frac{u^2 \sin^2 \alpha}{2g}$ and when the angle of projection is $(90^\circ - \alpha)$, the maximum height is given by:

$H_2 = \frac{u^2 \sin^2(90^\circ - \alpha)}{2g} = \frac{u^2 \cos^2 \alpha}{2g}$

Therefore, the ratio of maximum heights attained by them will be equal to: $\frac{H_1}{H_2} = \frac{\sin^2 \alpha}{\cos^2 \alpha} = \tan^2 \alpha$

ii. When the angle of projection is α, the horizontal range is $R_1 = \frac{u^2 \sin 2\alpha}{g}$ and when the angle of projection is $(90^\circ - \alpha)$, the horizontal range is given by:

$R_2 = \frac{u^2 \sin 2(90^\circ - \alpha)}{g} = \frac{u^2 \sin(180^\circ - 2\alpha)}{g} = \frac{u^2 \sin 2\alpha}{g}$

Therefore, $R_1 : R_2 = 1 : 1$

OR

Here we need to find the time of flight for each snowball. The time t_R is determined by v_{y0}, the vertical component of initial velocity, then we have

$t_R = \frac{2v_{y0}}{g} = \frac{2v_0 \sin \theta_0}{g}$

To find t_R we need to know, in addition to the initial angle θ_0 (as given), the initial speed v_0, which is not given. We can find v_0 by applying the range equation which is given by,

$R = \frac{v_0^2 \sin 2\theta_0}{g}$ ....(1)

Solving the above equation for v_0, we get, $v_0 = \sqrt{\frac{Rg}{\sin 2\theta_0}}$

We obtain the same value for v_0 whether we take,

$\theta_0 = 30^\circ$ or $\theta_0 = 60^\circ$

Since, $\sin 2(30^\circ) = \sin 2(60^\circ)$

$v_0 = \sqrt{\frac{(20)(9.8)}{\sin 60^\circ}} = 15.0$ m/s

For the first snowball,

$t_R = \frac{2(15)(\sin 60^\circ)}{9.8} = 2.65$ seconds

For the second snowball,

$t'_R = \frac{2(15)(\sin 30^\circ)}{9.8} = 15.3$ seconds

Thus, the waiting period is the difference between these two times and is given by:
$\Delta t = t_R - t'_R = 2.65 - 1.53 = 1.12$ s

29. The work-energy theorem states that the work done by a force acting on a body is equal to the change produced in its kinetic energy. If work W is being done on a body of mass m and due to the work done, the speed of the body changes from u to v, then Work done is given by:

    W = Change in its kinetic energy

    Therefore, $W = \Delta K = K_2 - K_1 = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$

    To derive the work-kinetic energy theorem analytically consider a body of mass m moving with a velocity u. Let a force $\vec{F}$ be applied on the body and under its effect body be displaced by $\overrightarrow{ds}$, so that we can write work done as:

    $dW = \vec{F} \cdot \overrightarrow{ds}$

    But we know that, $\vec{F} = m\vec{a} = m\frac{\overrightarrow{dv}}{dt}$

    Therefore, $dW = m\frac{d\vec{v}}{dt} \cdot ds = m\frac{ds}{dt}dv = mvdv$

    On integrating above equation, we obtain

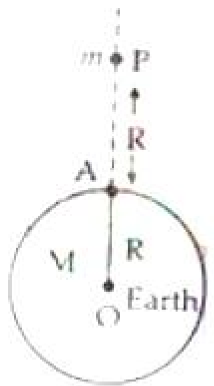
    $\int_0^W dW = W = \int_u^v mvdv$

    $= m\left[\frac{v^2-u^2}{2}\right] = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$

    Obviously, $\frac{1}{2}mv^2 - \frac{1}{2}mu^2$= change in K.E. = $K_f - K_i$.

    Thus, W = $K_f - K_i$ which is the work-kinetic energy theorem.

30. Let us consider earth as a uniform sphere and gravitational potential at infinite distance from earth as zero



According to the diagram shown below, where an object of mass m is raised from the surface of the earth to a distance (height) equal to the radius of the earth (R).

Initial potential energy of the object when it is at the surface of the earth

U_i = GMm/R $\frac{GMm}{2R}$

R where, M is the mass of earth and R is the radius of earth or distance of object from centre of earth.

Final potential energy of the object when it is at a height equal to the radius

U_f = – GMm/ 2 R $\frac{-GMm}{2R}$

P.E. of the object at a equal to the radius of earth $= \frac{-GMm}{(2R)}$

Gain in P.E= potential energy final- potential energy initial

Gain in P.E. = $\frac{-GMm}{2R} - \left(\frac{-GMm}{R}\right)$

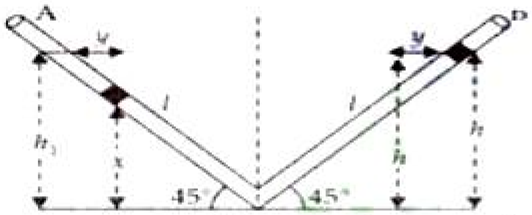
$= \frac{GMm}{R}\left[-\frac{1}{2}+1\right]$

$= \frac{GMm}{2R}$

Gain in P.E. = $\frac{gR^2m}{2R} = \frac{1}{2}mgR$

Section E

31. L et the liquid column in both arms of the V-tube were at h_0 heights initially. Now due to pressure difference the liquid columns in A arm is pressed by x and in arm B is liftted by x (so difference in vertical height between two levels $= 2x$) Consider an element of liquid of height dx inside the tube.



Then its mass $dm = volume \times density = A \cdot dx\rho$ (where, A =area of cross-section of tube, ρ = density of the liquid inside the tube)

Potential energy of the right arm with dm elementary mass column $= (dm)gh$

Potential energy of dm elementary mass in left arm column $= A\rho gxdx$ (putting the value of dm = $A.dx.\rho$ and h = x)

$\therefore$Total potential energy in left column $= \int_0^{h_1} A\rho gxdx = A\rho g\left[\frac{x^2}{2}\right]_0^{h_1}$

$= A\rho g\frac{h_1^2}{2}$

From above given figure $\sin 45^\circ = \frac{h_1}{l} \therefore h_1 = h_2 = l\sin 45^\circ = \frac{l}{\sqrt{2}}$

$\therefore h_1^2 = h_2^2 = \frac{l^2}{2}$

$\therefore$ Potential energy in the left column = $A\rho g\frac{l^2}{4}$

Similarly potential energy in right column$= A\rho g\frac{l^2}{4}$

$\therefore$ Total potential energy $= A\rho g\frac{l^2}{4} + A\rho g\frac{l^2}{4} = \frac{A\rho g l^2}{2}$

Due to pressure difference, left element moves towards right side by 'y' units and the same element rises in the right arm by 'y' units.

Then the liquid column length in the left arm becomes by decreasing $= (l - y)$

And the liquid column length in the right arm becomes by increasing $= (l + y)$

Now decreased potential energy of liquid column in the left arm $= A\rho g(l-y)^2 \sin^2 45^\circ$

Similarly increased potential energy of liquid column in the right arm

$= A\rho g(l+y)^2 \sin^2 45^\circ$

$\therefore$ Total potential energy due to two liquid columns in the left and right arm respectively

$= A\rho g\left(\frac{1}{\sqrt{2}}\right)^2 \left[(l-y)^2 + (l+y)^2\right]$

Final potential energy due to difference in liquid columns in the two arms,

$= \frac{A\rho g}{2}\left[l^2 + y^2 - 2ly + l^2 + y^2 + 2ly\right]$

$\therefore$ Final potential energy $= \frac{A\rho g}{2}\left(2l^2 + 2y^2\right)$

Now change in potential energy = Final potential energy due to liquid columns in the two arms– Initial potential energy due to liquid columns in the two arms

$= \frac{A\rho g}{2}\left(2l^2 + 2y^2\right) - \frac{A\rho g l^2}{2}$

$= \frac{A\rho g}{2}\left[2l^2 + 2y^2 - l^2\right]$

$\therefore$ Change in potential energy = $\frac{A\rho g}{2}\left(l^2 + 2y^2\right)$

If change in velocity (v) of total liquid column be v then change in kinetic energy,

$\Delta KE = \frac{1}{2}mv^2$

$Again\ m = volume \times density = (A.2l)\rho$

$\therefore \Delta KE = \frac{1}{2}(A2l\rho)v^2 = A\rho l v^2$

$\therefore$ Change in Total energy = change in potential energy + change in kinetic energy

$= \frac{A\rho g}{2}\left(l^2 + 2y^2\right) + A\rho l v^2$

Again, from the law of conservation of energy, total change in energy

$\Delta PE + \Delta KE = 0$

$\therefore \frac{A\rho g}{2}\left[l^2 + 2y^2\right] + A\rho l v^2 = 0$

$\therefore \frac{A\rho}{2}\left[g\left(l^2 + 2y^2\right) + 2lv^2\right] = 0$

$\because \frac{A\rho}{2} \neq 0$

$\therefore g\left(l^2 + 2y^2\right) + 2lv^2 = 0$

Differentiating on both sides of the above equation with respect to time,t we get

$g\left[0+2\times 2y\frac{dy}{dt}\right]+2l.2v\cdot\frac{dv}{dt}=0$

$\therefore 4gy\frac{dy}{dt}+4vl\frac{d^2y}{dt^2}=0\left[\because a=\frac{dv}{dt}=\frac{d^2y}{dt^2}\right]$

$\Rightarrow 4gy\cdot v+4vl\frac{d^2y}{dt^2}=0\Rightarrow 4v\left[gy+l\cdot\frac{d^2y}{dt^2}\right]=0$

$\Rightarrow \frac{d^2y}{dt^2}+\frac{g}{l}y=0\quad \because 4v\neq 0$....(i)

It is the equation of a simple harmonic motion and can be compared with the standard equation of a simple harmonic motion i.e. $\frac{d^2y}{dt^2}+\omega^2y=0$.....(ii) [$\omega$ is the angular acceleration or angular frequency of the particle executing simple harmonic motion]

Comparing the above two equations (i) and (ii) we get, $\therefore \omega^2=\frac{g}{l}$

$\therefore \frac{2\pi}{T}=\sqrt{\frac{g}{l}}\Rightarrow T=2\pi\sqrt{\frac{l}{g}}$ [$\because \omega=\frac{2\pi}{T}$, T being time period of the simple harmonic motion]

OR

Mass of the automobile, m = 3000 kg

Displacement in the suspension system, x = 15 cm = 0.15 m

There are 4 springs in parallel to the support of the mass of the automobile.

The equation for the restoring force for the system:

F = -4kx = mg

Where, k is the spring constant of the suspension system

Time period, $T=2\pi\sqrt{\frac{m}{4k}}$

And $k=\frac{mg}{4x}=\frac{3000\times 10}{4\times 0.15}=5000=5\times 10^4 N/\text{m}$

Spring constant, $k=5\times 10^4 N/m$

a. Each wheel supports a mass, M = $\frac{3000}{7}$ = 750 kg

   For damping factor b, the equation for displacement is written as:

   $x=x_oe^{-bt/2M}$

   The amplitude of oscillation decreases by 50%.

   $\therefore\ x=\frac{x_0}{2}$

   $\frac{x_0}{2}=x_0e^{-bt/2M}$

   $\log_e 2=\frac{bt}{2M}$

   $\therefore b=\frac{2M\log_e 2}{t}$

   Where,

Time period, $t = 2\pi\sqrt{\frac{m}{4k}} = 2\pi\sqrt{\frac{3000}{4\times5\times10^4}}$ = 0.7691 s

$\therefore b = \frac{2\times750\times0.693}{0.7691}$

= 1351.58 kg/s

Therefore, the damping constant of the spring is 1351.58 kg/s.

32. We know that in a state of thermal equilibrium, in accordance with the equipartition law of energy, the average energy associated with each degree of freedom is $\frac{1}{2}k_BT$.

If a gas molecule has n degrees of freedom in all, then the average energy per molecule of gas

$= n \times \frac{1}{2}k_BT = \frac{n}{2}k_BT$

As one mole of gas consists of N_A molecules, hence total internal energy of one mole of given gas will be given by

$U = N_A \times \frac{n}{2}k_BT = \frac{n}{2}RT$

where $R = N_A.k_B$ = universal gas constant.

$\therefore$ Molar specific heat of given gas under constant volume condition will be given by

$C_v = \frac{dU}{dt} = \frac{d}{dT}\left[\frac{n}{2}RT\right] = \frac{n}{2}R$ ...(i)

For an ideal gas,

$C_p - C_v = R$

$\therefore$ Molar specific heat of given gas under constant pressure condition

$C_p = C_v + R = \frac{n}{2}R + R = (n+2)\frac{R}{2}$ ....(ii)

$\therefore \gamma = \frac{C_p}{C_v} = \frac{(n+2)\frac{R}{2}}{n\frac{R}{2}} = \frac{n+2}{n} = \left(1+\frac{2}{n}\right)$ ...(iii)

Thus, it is clear that the values of principal specific heats of gas, as well as their ratio, depends on the number of degrees of freedom per molecule of the given gas.

OR

a. **Moon** is considered **not** to **have an atmosphere** because it cannot absorb measurable quantities of radiation, **does not** appear layered or self-circulating, and requires constant replenishment due to the high rate at which its gases are lost to space.As acceleration due to gravity on moon is 1/6th of g on earth. So the escape velocity on moon

$V_{ez} = \sqrt{2gR} = 2.38\text{km}/s$

M = Mass of hydrogen, As H_2 is lightest gas $m = 1.67\times10^{-24}kg$

$v_{rms} = \sqrt{\frac{3K_BT}{m}} = \sqrt{\frac{3\times1.38\times10^{-23}\times300}{1.67\times10^{-24}}}$= 2.72 km/s

Due to small gravitational force and v_{rms} is greater than escape velocity so molecule of air can escape out.

As the distance of moon from sun is approximately equal to that of earth so the intensity of energy of sun reaches to moon is larger due to lower density of atmosphere, distance become smaller than earth when moon is towards sun during its rotation around earth.

Due to this (sun light), root-mean-square speed of molecule increase and some of them can speed up more than escape velocity and so probability of escaping out increased.

Hence over a long time moon has lost most of its atmosphere.

b. The temperature of atmosphere is due to the kinetic energy of air molecule. Due to lower atmospheric pressure at higher altitude molecules of air rises up so their potential energy increase, in turn, the kinetic energy decrease results the decrease in temperature. Due to lower atmospheric pressure at higher altitude, the gas expands and gives cooling effect and so decrease the temperature.

33. Young's modulus for steel:

$$Y_1 = \frac{\left(\frac{F_1}{A_1}\right)}{\left(\frac{\Delta L_1}{L_1}\right)}$$

Where,

ΔL_1 = Change in the length of the steel wire

A_1 = Area of cross-section of the steel wire = πr_1^2

Young's modulus of steel, $Y_1 = 2.0 \times 10^{11}$ Pa

$$\therefore\ \Delta L_1 = \frac{F_1\times L_1}{A_1\times Y_1} = \frac{F_1\times L_1}{\pi r_1^2\times Y_1}$$

$$= \frac{98\times1.5}{\pi(0.125\times10^{-2})^2\times2\times10^{11}} = 1.49\times10^{-4}\text{m}$$

$\textit{Total force on the brass wire}:\ F_2 = m_2 g$

$F_2 = 6 \times 9.8 = 58.8\ N$

Young's modulus for brass:

$$Y_2 = \frac{\left(\frac{F_2}{A_2}\right)}{\left(\frac{\Delta L_2}{L_2}\right)}$$

Where,

ΔL_2 = Change in length

A_2 = Area of cross-section of the brass wire

$\therefore \Delta L_2 = \frac{F_2 \times L_2}{A_2 \times Y_2} = \frac{F_2 \times L_2}{\pi r_2^2 \times Y_2}$

$= \frac{58.8 \times 1.0}{\pi(0.125 \times 10^{-2})^2 \times (0.91 \times 10^{11})} = 1.3 \times 10^{-4} m$

Elongation of the steel wire = 1.49×10^{-4}m

Elongation of the brass wire = $1.3 \times 10^{-4} m$

OR

If the rod fetches along its length then the stress produced is the tensile stress whereas the strain produced is a longitudinal strain.

Radius $= 8mm = 8 \times 10^{-3} m$

Length, $L = 2m$

Force, $F = 150\ kN = 15 \times 10^4 N$

Area, A = πr^2 = $\pi \times (8 \times 10^{-3})^2 = 201 \times 10^{-6} m^2$

$\Delta L = 7.46\text{mm} = 7.46 \times 10^{-3} m$, percentage strain = ?

Stress = $\frac{F}{A}$ = $\frac{15 \times 10^4}{201 \times 10^{-6}} = 0.0746 \times 10^{10} N/m^2$

$= 7.46 \times 10^8 N/m^2$

Longitudinal strain = $\frac{\Delta L}{L}$ = $\frac{7.46 \times 10^{-3}}{2}$ = 3.73×10^{-3}

Percentage strain = $3.73 \times 10^3 \times 100$ = 0.37 %